

Final Report

Completion of Repairs to the Shenandoah (Georgia)
Community Center Solar Heating, Cooling, and Hot Water System

Submitted to

U. S. Department of Energy

Contract
EY-76-S-05-4942, Mod 5

by

Georgia Institute of Technology
College of Engineering
Atlanta, Ga. 30332

Technical Monitor

Mr. John Crane
PRC Energy Analysis Co.
McLean, Virginia 22101

Project Director

Dr. J. R. Williams
Associate Dean for Research
College of Engineering

Report Prepared by

Dr. Sheldon M. Jeter
Research Engineer
Engineering Experiment Station
Energy Research Laboratory
Phone: (404) 894-3283

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Abstract

The development, implementation, and operation of an enhanced freeze-protection system for the Shenandoah Solar Community Center in Shenandoah, Georgia, is described. Freeze damage incurred primarily during the winter of 1977-1978 was repaired which entailed closing scores of leaks in absorber tubes, collector headers, module headers, and supply piping along with the replacement of most of the exterior pipe insulation. To prevent further damage, an isolation heat exchanger has been installed to allow the array to be filled with a water/glycol solution during cold weather periods. Operational and maintenance manuals for the system were prepared and training provided to the operator.

Technical Summary

The work covered under this contract (EY-76-S-05-4942, Mod 5) consists of four distinct tasks

- (1) Repair of freeze-damage to the collector array which occurred during the winter of 1977-1978 and some further damage which occurred during 1978-1979.
- (2) Upgrading the freeze protection system by installing an isolation heat exchanger which allows a water-glycol solution to be circulated through all exposed tubing during winter.
- (3) Preparation of operating manuals for the system and the major components.
- (4) Instruction and training of operating and maintenance personnel.

As detailed in the narrative, repair of freeze damage to the collector array was one of the most time-consuming parts of this project. Much work had to be accomplished during the spring and summer of 1978, prior to the award of this contract, to close the leaks in the collector modules and exposed piping. Most of the remaining leaks were repaired during the early spring of 1979. All remaining leaks have now been closed, and the damaged insulation and flashing replaced.

The isolation heat exchanger has been installed in the mechanical area along with auxiliaries and control modifications to allow a winter mode of operation with a water-glycol solution in the array and a summer mode with water in the array. The glycol is held during summer in an auxiliary tank. The modes of operation are as shown in Figures 1 and 2.

Maintenance and operating manuals have been prepared by the persons most familiar with the system and its operation. These manuals also include a full set of manufacturers manuals for all the major components.

The building operator has been provided formal and on-job training to the maximum extent possible.

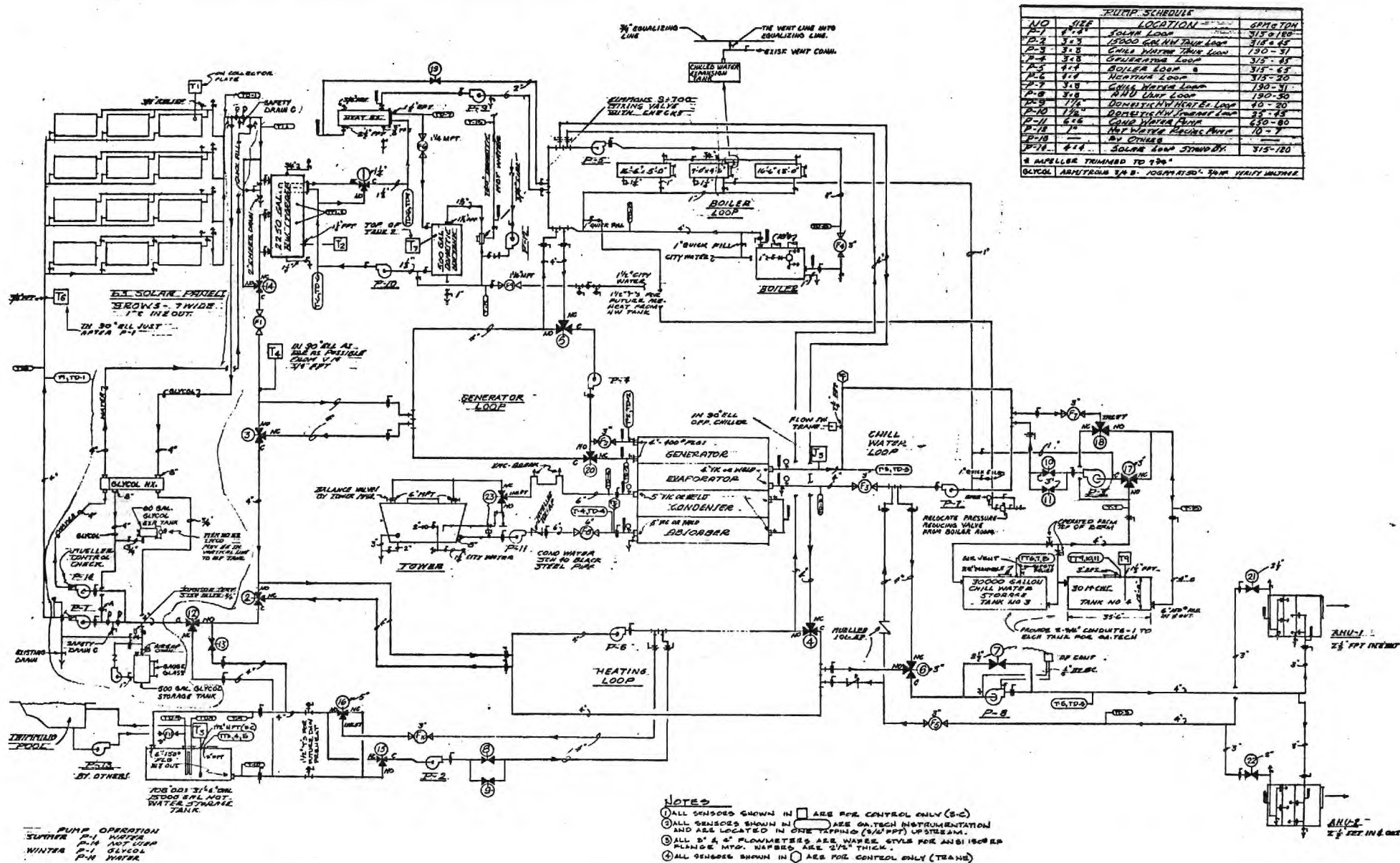


FIGURE 1. THE SHENANDOAH SOLAR SYSTEM IN SUMMER MODE OF OPERATION. Water is circulated in the array for highest collection efficiency during the cooling season. Glycol solution is held in storage tank.

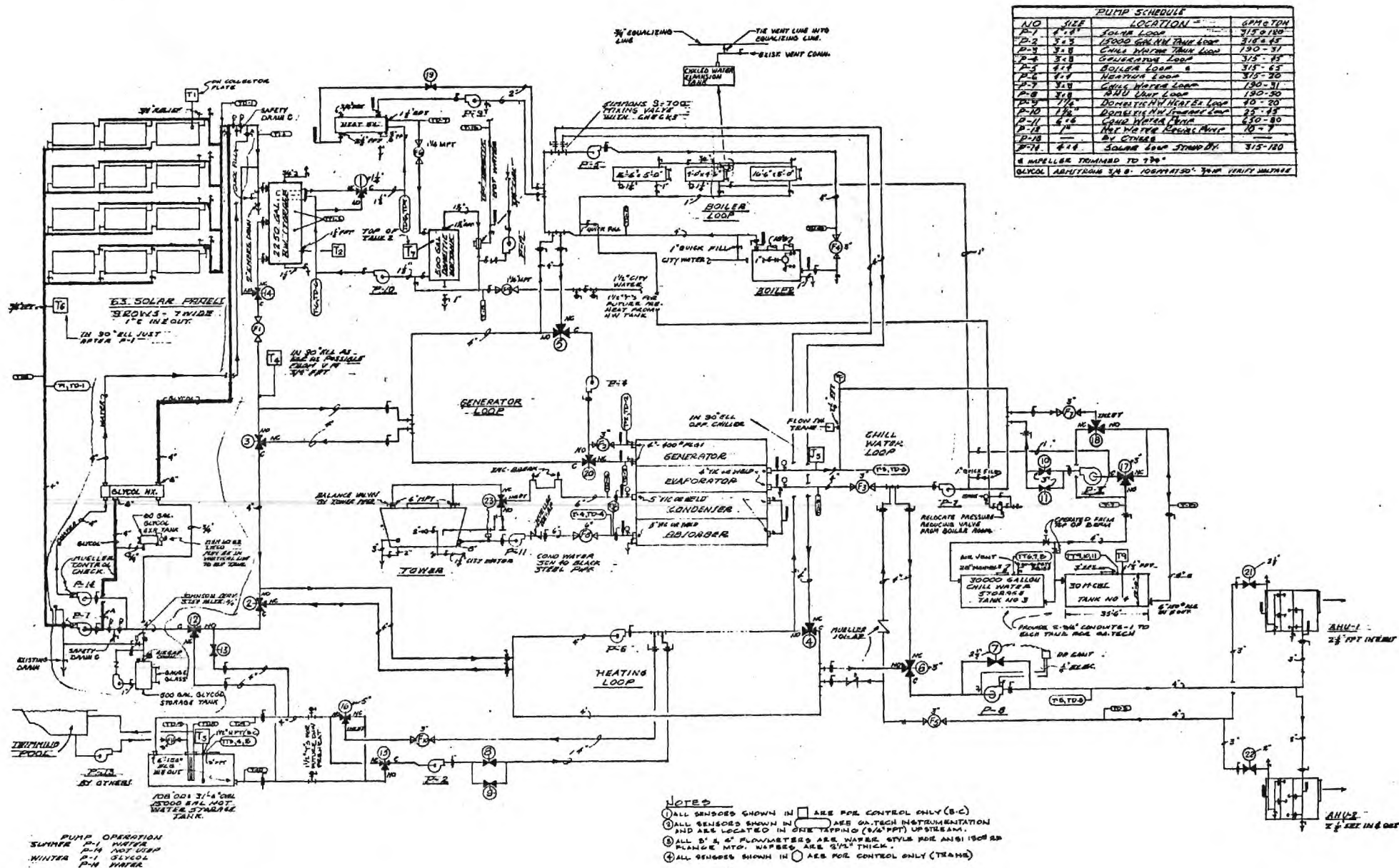


FIGURE 2. SHENANDOAH SYSTEM IN WINTER MODE OF OPERATION. Glycol/Water solution fills all exposed piping in the collector loop (bold lines). Water in balance of system is heated in isolation heat exchanger.

Narrative

Subsequent to the extensive freeze damage to the exposed collector and manifold piping in the Shenandoah system incurred during the severe winter of 1977-1978, the array was drained as thoroughly as possible and the solar collection system deactivated for the balance of the winter.

During the Spring of 1978, arrangements were finally completed with Revere Solar Products to replace the bellows-type expansion compensators with the Amtrol series 1300 concentric-tube expansion joint. This repair was effected by representatives from Revere aided by a team of students from Georgia Tech. With the unsatisfactory bellows-type expansion joints removed, it became at least marginally possible to drain the array which made it feasible to begin repairs to the damaged collectors and array piping.

Although funds from the construction project were essentially exhausted or encumbered, repairs were begun by Georgia Tech personnel. The repairs were made possible by using some funds from the original project as authorized in the letter from Mr. John Crane on 31 March 1978, by using some institutional funds provided by the College of Engineering, and most importantly volunteer work by several faculty and graduate students during weekends. It was not possible to replace the damaged insulation in the array because of the significant material expense involved; however, the system was reactivated with nearly all leaks repaired in June of 1978. The system continued to operate basically well during the summer and fall of 1978 except for a malfunction in a temperature sensor which inhibited effective solar contribution to cooling. In the absence of an effective state and performance monitoring system, it was difficult to discover the presence and cause

of this problem, however, the building operator was able to observe that a problem existed because of the excessive array temperatures using the rudimentary data available, and he reported the problem in August 1978. Mr. Tom Hartman, of Georgia Tech, investigated the problem and recommended the appropriate corrective action.

On 31 May 1978 a proposal was submitted to Mr. John Crane of PRC to accomplish needed repairs on the building, provide a fail-safe freeze-protection system, and provide operational training and manuals. Mr. Crane reviewed this initial letter proposal and recommended some revisions as well as requiring more specific cost data in certain categories. The additional information was provided in a new proposal that was submitted on 16 June 1978. Although formal work on the building was suspended awaiting action on this proposal and in view of the extremely limited funds which remained, personnel from Georgia Tech continued to advise and assist the building operator, usually on personal time, in the subsequent months.

The proposal sent to PRC on 16 June 1978 was reviewed over a period of several months, and the actual contract was not signed until 28 September, 1978. The budget was submitted at Georgia Tech and a project account established allowing work to begin on 5 October 1978.

Between 5 October and 10 October 1978, we formalized concepts for three alternative freeze protection schemes and evaluated them in detail for reliability, energy performance, and prospective costs. The Shenandoah Corporation was especially concerned about future operating costs, reliability, and impact on maintenance of the alternative modifications.

The proposed options were as follows:

OPTION 1: NATURAL GAS FIRED ELECTRIC GENERATOR/CITY WATER BACKUP

I. WHEN THE POWER FAILS:

Emergency generator turns on.

1. Powers recirculation pump
2. Powers small compressor for required controls

II. POWER FAILS AND EMERGENCY GENERATOR FAILS

1. No pneumatic supply available
2. City water runs through collectors and out drain

ADVANTAGES:

1. Minimal chance of failure. Proper choice of inlet water location and drain will allow partial drain, limiting damage to lower headers, even if city water supply should fail.
2. Minimal replacement of corrosion inhibitors.

DISADVANTAGES:

1. Maintenance of engine-generator set
2. If city water supply is required, will cost approximately \$3.15/hour

COST ESTIMATE EQUALS \$25,350.00

OPTION 2: NATURAL GAS FIRED ELECTRIC GENERATOR/DRAIN DOWN

I. WHEN POWER FAILS:

Emergency generator turns on.

1. Powers recirculation pump
2. Powers small compressor for required controls

II. POWER FAILS AND EMERGENCY GENERATOR FAILS

1. No pneumatic supply available
2. Collector array drains

OPTION 2 (cont.)

ADVANTAGES:

1. Minimal change of failure
2. Minimal replacement of corrosion inhibitors
3. City water only used for make up

DISADVANTAGES:

1. Maintenance of engine generator set
2. Don't know if array can be made drainable
3. Difficult start up

COST ESTIMATE EQUALS \$27,000.00

OPTION 3: DRAIN DOWN

I. WHEN POWER FAILS:

Array Drains

ADVANTAGE:

Lowest cost (possibly)

DISADVANTAGE:

1. Don't know if array is drainable
2. Difficult start up
3. Loss of corrosion inhibitor

COST ESTIMATE EQUALS: \$11,000.00

On 10 October representatives from Georgia Tech, Shenandoah, PRC and the subcontractors met at Shenandoah to examine these alternatives and arrive at a consensus opinion as to which should be pursued. The decision was that a natural gas-powered electrical generator would be installed so that the

recirculation pump could be powered in the event of an electrical outage, (which are frequent in the system serving the building) and should the generator also fail during the outage, city water would flush the array until power was restored. During the next 9 days Georgia Tech and the engineering subcontractor (Newcomb and Boyd Engineers) prepared detailed specifications to permit competitive procurement of this installation. Various generator manufacturers were also contacted and a suitable gas-fired generator which could be delivered very quickly was located. The controls subcontractor developed the design for the necessary control modifications and the insulation subcontractor prepared bids for the necessary insulation work.

Newcomb and Boyd Engineers had been retained as an engineering consultant on this project for several reasons. Primarily, they had acted as the mechanical engineering consultant for the construction of the building and were most familiar with all details of the building. It was also felt that a firm employing registered professional engineers should accomplish the final design documents and specifications. Additionally, employing Newcomb and Boyd provided continuity in the project, and because of their previous involvement in the building, their services were offered at a very favorable rate.

On 20 October, Newcomb and Boyd contacted Georgia Tech and suggested a new approach involving the use of glycol in the collector loop but eliminating some of the difficulties originally envisioned for a glycol system. This suggestion was investigated carefully while work continued on the generator concept. Numerical models were prepared for both concepts and computer simulations were performed using the Shenandoah Solar Model Year (developed here under contract to Sandia Labs) to compare operating costs and performance.

By November 1, detailed specifications and costs had been determined for both types of freeze protection systems. It was found that both capital costs and operating costs of the two approaches were nearly identical. Another meeting of Georgia Tech, Shenandoah, PRC and subcontractor representatives was held 7 November and after considerable discussion a consensus was reached in favor of the glycol approach. The primary reason for selecting the glycol-loop alternative was a general concern that flow through the large array which had already been significantly damaged by freezing would not be sufficiently uniform to prevent freezing in isolated segments. An additional concern was that with recirculation the stored heat capacity might frequently be exhausted requiring the revision to fresh water circulation as a back-up. The glycol system was felt to be simpler and more reliable (since stagnant regions would not freeze) as well as self-sufficient requiring no back-up or emergency intervention. The drain-back alternative was dismissed as it was evident that the array and its piping could not be modified to ensure drainage without major alterations.

Since initiation of modifications were delayed by the late effective date of the contract and implementation would be further delayed somewhat by lead-time on the heat exchanger required for the much-preferred glycol system, it was decided to drain the array to avoid damage during the upcoming freezing weather. To facilitate better drainage, several dozen drain cocks and drain couplings were installed in obvious low spots in the array manifolds and supply piping and the exposed piping and collectors were drained as thoroughly as practical.

During the balance of October, 1978, efforts were concentrated on selecting major components and contractors for the mechanical work. There was some unavoidable duplication of effort since costs were obtained for

both the auxiliary generator system and the isolated glycol-loop alternative for comparison.

Early in November 1978, purchase orders were submitted for the isolation heat exchanger and insulation of the modified piping in the mechanical area along with insulation of the supply piping to the collectors. To conserve funds, it was decided that Georgia Tech would accomplish the insulation of the collector module manifolds as this was the most complicated and labor-intensive insulation work. Also, this arrangement would allow us to repair and inspect the collectors and manifolding without interfering with the insulation contractor. Also during November we prepared detailed responses to the building owners concerns relative to the use of glycol in the system. The primary concern was, of course, safety, and it was emphasized that throughout the design potable water was always protected from the glycol solution by at least two metal walls. In the case of the change-over valves, two valves and an intermediate drain separate the glycol from the water in the balance of the system which is further separated from the potable water supply itself. It was also noted that the approximately 250 gallons of glycol in the collector loop would be diluted by more than 75,000 gallons in the balance of the system in the event of an unforeseen malfunction or operator negligence that mixed the fluid, and even in this case, the potable water supply would remain isolated.

Later in November, it became obvious that the scheduled completion date of 31 December 1978 could not be met. The reasons for the delay were as follows:

- (1) The time spent in evaluating alternative protective schemes
- (2) A projected 10 week delivery schedule on the heat exchanger which was longer than expected but less than the actual time finally required.
- (3) The need to repair the array, complete modifications, and test the system charged with glycol before installing insulation.

In view of these circumstances, a no-cost schedule extension was eventually granted authorizing work until the end of May 1979.

By December the isolation heat exchanger had been ordered and the mechanical and insulation contractors had been selected. Additionally, preliminary work had begun on compiling and editing the maintenance and operational manuals.

A significant but unavoidable delay occurred in January and February 1979. The manufacturer had promised delivery of the isolation heat exchanger in early January. We had expected delivery by at least the middle of the month allowing for the usual overstatement of ability to meet delivery commitments. The exchanger was, however, delayed even more and was apparently not completed until early February. At that time the exchanger failed its pressure test creating a further delay. We were thankful, however, that the vessel failed at the factory rather than after installation.

In early February it became apparent that budget problems were possible if costs were not controlled. The primary reason for the budget difficulty was the quotation from the mechanical contractor for the installation of the isolation heat exchanger and associated components. The quoted cost of \$13,038 was nearly \$5,000 more than estimated by our engineering consultant. The deficiency was made-up by Georgia Tech's undertaking certain tasks such as rework of the controls and insulation of the array which would normally be contracted and by additional funds made available by the Shenandoah Development Corp. Also during February the maintenance manual was completed.

In early March, the heat exchanger finally arrived and the mechanical contractor set to work speedily to make the needed modifications. The usual problems were encountered in modifying an existing system, but all were alleviated by field corrections since Georgia Tech had a representative at the building continually to monitor and supervise the work.

In late March the mechanical modifications and control modifications were complete and we proceeded to fill the system and array to check for leaks. Some minor leaks were discovered in the mechanical area which were easily corrected. Unfortunately, it was found that a number of leaks, some of which were significant, existed in the array and exposed piping. Many of these leaks probably happened because of freezing during the winter of 1978-79 when the array had been drained as thoroughly as practical. This occurrence emphasized that a drain-back option for freeze protection would have been impossible without nearly complete rework of the entire array and manifolds. The system was sealed as much as possible, however, this repair was very slow because of the inherent difficulty of finding and fixing leaks, especially those in the collector tube sheets. After operating the system in its winter mode for about one month primarily to check for leaks and compatibility with the glycol, the glycol was drained and the system returned to the summer mode with water in the array. The system worked well in its winter mode although during early spring the predominate load is only domestic hot water. The only difficulty encountered was a slight undersizing of the glycol holding tank which we consider to have been caused by not accounting for the volume of solution in the heat exchanger shell and the expansion tank. This will create no great difficulty during seasonal changeovers, and to avoid loss of glycol during over-temperature drain backs, a boiler water level control valve will be installed at the holding tank during the change-over for the 1979-1980 winter.

The insulation contractor finished work in the mechanical area and on the collector supply piping during May and Georgia Tech completed the insulation of most of the collector modules during early July. The insulation of the modules went very slowly for several reasons:

- (1) It was necessary to find and correct leaks before installing insulation.
- (2) The aluminum flashing was difficult to fit back into place and new mounting holes had to be punched for each of several hundred screws.
- (3) Working next to the heated collectors and under the concentrated radiation from the augmenting reflectors was exhausting and difficult.

By the end of July 1979 all repairs were completed and the system had operated several weeks with glycol in the array in the winter mode and with water in the array in the summer mode. Some repairs remained to be completed to leaking collector, but at present all but one collector have been fixed. The delay in fixing collectors is strictly due to the difficulty in finding and fixing the leaks which are usually small and most frequently on the underside of the absorber; however, Georgia Tech personnel in cooperation with Shenandoah, continue to monitor the system particularly with regard to proper adjustment of the control settings and ensuring that all leaks are eliminated from the system.

At present (September 1979), the system is essentially fully operational in its summer (water in collectors) mode. All repairs of freeze damage (except one obscure leak in a single collector of the 441 collectors in the array) have been finished, the building operator has been trained to the fullest extent possible, and maintenance and operation manuals have been written and provided. Work did proceed past the 31 May 1979 deadline primarily because of scheduling difficulties; however, all work past that date was supported by funds provided by the Shenandoah Corporation or was provided without cost.

Monthly and Trip Reports of
Special Interest

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF

MECHANICAL ENGINEERING

June 16, 1978

Mr. John Crane
PRC Energy Analysis Company
7600 Old Springhouse Road
McLean, Virginia 22101

Dear Mr. Crane:

In response to your latest request on 15 June 1978, we have prepared the following proposal for the completion of repairs to the Shenandoah Solar Community Center,^o upgrading the freeze protection system, preparation of SOP and operating manuals, and instruction and training of the building maintenance and operative staff.

1. Completion of Freeze-damage Repairs

<u>Personal Services</u>	<u>Labor</u>	<u>Material</u>
GRA 1/3 time for 1 month		
Salary	\$ 500	
Overhead	380	
	880	
Contracted Services:		
(a) replace insulation and waterproof exposed supply headers (includes insulation, sealant and flashing)	684	\$ 684
unit costs:		
insulation \$1.83/ft		
flashing 2.70/ft		
(b) replace insulation on all module internal manifolds	1199	1199
unit cost: \$1.73/ft		
(c) waterproof module headers at joints (378 places)	500	500
Materials: construction materials for initial or follow-up work by Tech personnel		100
Travel: 10 trips to site		100
	\$ 3263	\$ 2583
Total for task: \$5,846.00		

2. Upgrading Freeze-protection System

The current procedure for freeze-protection, primarily because of its reliance on timely human intervention in the advent of a power interruption, has proved itself to be unreliable.

This task will involve the design and installation of modifications to the system to allow a closed collector loop containing an antifreeze solution (or other cost-effective solution, if further work indicates this is not feasible). The following costs have been estimated from a conceptual design of this modification.

Equipment	Labor	Material
generator loop HX		\$ 1448
heating loop HX		3799
750 gal expansion tank		<u>1150</u>
		6397
Contracted services		
install HX's	\$ 1000	500
install HX pipe (c. 120')	1734	744
insulate HX's and pipe	980	420
install exp. tank	300	100
insulate exp. tank	497	<u>213</u>
	<u>4511</u>	<u>1977</u>
Professional services		
consulting P.E.	900	
drawings	<u>150</u>	
	<u>1050</u>	
Antifreeze solution		
1600 gal. at \$3.00/gal		4800
transfer pump and fittings	<u>300</u>	<u>200</u>
	300	5000
Personal services		
GRA: 1/3 time, 1 month	500	
faculty: full time, 1 month	2333	
overhead	2153	
retirement	<u>265</u>	
	<u>5251</u>	
Travel:		
10 trips to site		<u>100</u>
	<u>\$11,112</u>	<u>\$13,474</u>

Total for task: \$24,586

Mr. John Crane
June 16, 1978
Page Three

3. Preparation of Operating Manuals

Personal Services	Labor	Material
faculty, 1 month	\$ 2333	
GRA, 1 month, 1/3 time	500	
overhead	2153	
retirement	<u>265</u>	
	5251	
 Professional Services		
drafting and drawings	100	
Reproduction	<u>5351</u>	\$ <u>100</u> 100

Total for task: \$5,451.00

4. Instruction and training of operating and maintenance personnel

Personal Services		
faculty, 2 weeks	1167	
GRA, 3 weeks, 1/3 time	335	
overhead	1141	
retirement	<u>109</u>	
	2752	
 Travel		
10 trips	\$ <u>2752</u>	<u>100</u> \$ 100

Total for task: \$2,852.00

The total proposed cost is: \$38,735.00. If there are any questions, please call.

Very truly yours,

Sheldon M. Jeter
Research Engineer

SMJ/cs

SHENANDOAH TRIP REPORT
October 2, 1978

Met with Darrell Hester at Shenandoah building at 11:00 a.m. on 10-2-78 for first of regular bi-weekly meetings on problems with the Recreation Center.

Personnel from Trane were at the site bringing the chiller back on line. Chiller was down since last Thursday (9-28) due to boil off of refrigerant. A long discussion brought up the following points:

1. The chiller will boil off all refrigerant whenever there is a cooling load, the solar system cannot meet it, and the boiler breaks down.
2. The under temperature control will not let the chiller start unless high enough temperatures are obtained.
3. If the temperature in the generator loop falls below the minimum required, the under temperature sensor will not shut down the system. This leads to an expensive service call from Trane.
4. The B.C. aquastat appears to be working properly and in reasonable calibration.
5. The conclusion is the under temperature protection is under fired. Trane recommends connecting it to chiller terminal LL-1. Recommended that Darrell talk to Tom Dyer at B.C.
6. In addition, it appears that the automatic controls on P-7 override the manual. Is this desirable? Is this safe?

Except as noted above the system is running properly in all modes.

Left Shenandoah at about 12:30 p.m.

Thomas L. Hartman

TLH/cs

SHENANDOAH TRIP REPORT
12-5-78

On arrival got the key to the Met Station at the Peach Barn and proceeded to examine the insolation monitoring equipment. This was about 10:45 a.m. EST. All three pyrhemometers were improperly aligned. Not only was the spot off center on the target, it wasn't hitting the target at all. It appeared to be tracking OK on the time axis, but the declination adjustment was considerably off. The shadow band pyranometer was incorrect with regard to hour and declination. No adjustments were made. Grading and site preparation have started, and there are clouds of dust everywhere.

Talked to Darrell Hester. System OK with exception of P-8, which we already know about. If we bring down a new 3/4" thermowell, he will replace the one on the chiller loop next week.

Examined the piping in the mechanical room at the building. TB-1 is not where shown on the drawings, but there is an empty thermowell there. Pneumatic reserve for controls is at 70 psig, and to the B-C panel is at 22 psig.

Thomas L. Hartman III

GEORGIA INSTITUTE OF TECHNOLOGY

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MECHANICAL ENGINEERING

January 15, 1979

MONTHLY REPORT -- SHENANDOAH MODIFICATION -- E-15-618

This report covers the work accomplished on contract E-15-618 (Mod A005 to EY-76-S-05-4942) through 12-30-78.

Work is proceeding approximately on schedule on the modifications to the Shenandoah Building.

All required components are on order, and deliveries of most are expected the week of 1/14/79. An authorization to proceed will be issued to the mechanical contractor the week of 1/14/79. The cost of the mechanical modifications is considerably higher than anticipated, but with care may be accommodated in the existing budget.

Maintenance procedures for the chiller, air handling units, cooling tower circulating pump, boiler and circuit setters have been received from the manufacturers. Maintenance procedures for the remaining circulating pumps and the cooling tower will be obtained next week. The section of the operations and maintenance manuals dealing with the controls are currently being written. Due to the complexity of the controls, this portion of the task is taking somewhat longer than anticipated.

After delivery of the heat exchanger the mechanical contractor will start work in approximately one week, and he anticipates that it will take two weeks to complete the modification. The conventional HVAC system will have to be shut down for only one day during this period of time.

While the requested no cost extension has not been received yet, we understand from John Crane of PRC that it is coming, and we are proceeding on that basis.

Thomas L. Hartman

TLH/cs

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February 12, 1979

Mr. John D. Crane, Jr.
PRC Energy Analysis Company
7600 Old Springhouse Road
McLean, Virginia 22101

Dear John:

Enclosed is the latest monthly narrative report on the Shenandoah modifications. The failure of the HX during pressure tests will undoubtedly cause further delays. It is surprising that any vessel would fail at the pressure for this installation, but thankfully the problem was discovered at the factory and not after installation.

Also attached is the latest budget position, and it appears that the project will be completed as budgeted since we have had enough time to make adjustments to counteract the higher than originally estimated mechanical contract. As I said before, the mechanical contract now seems reasonable (or even rather low), and it is the original estimate by our A/E consultant that appears to have been too low.

Thanks for your continued personal interest and support. We continue to push for an early completion of this project.

Very truly yours,

Sheldon M. Jeter
Sheldon M. Jeter
Research Engineer

CS
attachments

GEORGIA INSTITUTE OF TECHNOLOGY

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MECHANICAL ENGINEERING

February 8, 1979

MONTHLY REPORT -- SHENANDOAH MODIFICATION -- E-15-618

This report covers the work accomplished on Contract E-15-618 (Mod A005 to EY-76-S-05-4942) through 1-31-79.

Work on the freeze protection system modification for the Shenandoah Recreation Center has been somewhat delayed during the month of January. This has been unavoidable due to the late delivery of the heat exchanger. Originally the manufacturer promised an eight week delivery. The schedule allowed for ten weeks, anticipating that as usual some delays were to be experienced. The heat exchanger was, therefore, expected in mid-January. Due to a backlog of orders the manufacturer experienced an even longer delay than even we anticipated. The manufacturer finally assured us that the heat exchanger would be tested and then shipped on 2-2-79. On that date the unit failed its ASME pressure test due to a defective weld in the bonnet head. We are assured that the unit will be shipped on 2-7-79. Needless to say, for the past several weeks we have been in frequent contact with the manufacturers representative, trying to speed up delivery.

In the meantime all contractual arrangements have been made with the mechanical contractor, and he is ready to start work as soon as the heat exchanger arrives.

The only contract left to award is the insulation subcontract. A specification has been prepared. This will shortly be released to the prospective contractor for quotes. Replies will be expected at the time the mechanical modifications are complete.

The maintenance manual has been written and is now undergoing review. It is anticipated that the operations manual will be completed in the next two weeks. Formal training of the building owner's personnel will start simultaneously with the mechanical modifications.

Assuming no further delay is experienced in component delivery, contract completion is expected on time and within budget.


Thomas L. Hartman

TLH/cs

REPORT ON SHENANDOAH BUDGET

February 9, 1979

Expenses to Date

Newcomb and Boyd	\$ 1,800	
Heat exchanger	5,276	
Insulation	922	
Eastern Mechanical	13,038	
Controls	200	
Mechanical Engineering Dept.	2,551	
Miscellaneous	659	
	<u>\$24,446</u>	-\$24,446

Expenses to be Incurred (estimated)

Insulation	\$ 5,000	
Electrical modification	200	
Additional controls	50	
Labels and tags	175	
Miscellaneous	500	
	<u>\$ 5,925</u>	-\$30,371

Operating Supplies and Equipment (E-15-618)	\$30,161.21	
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Additional from E-15-608	986.49	
	<u>\$31,147.70</u>	+ 776.70

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SHENANDOAH FREEZE-PROTECTION MODIFICATION
PROJECT REVIEW: 21 FEBRUARY 1979

1. Mechanical Modifications: Drawings and specs for all mechanical and instrumentation changes appear to be in order. Georgia Tech will request estimates on corrosion control treatments from contractors recommended by Newcomb and Boyd. The fluid corrosion sensor should be requested from the DOE immediately so it can be installed along with the HX. If the HX arrives this week as now expected, modifications should be completed by mid-March.
2. Electrical Modifications: Instrumentation changes are minor and will be completed by Georgia Tech. The power wiring can be done by Georgia Tech and Shenandoah personnel. Standard practices are sufficient to define this minor work.
3. Structural Compatibility: No hoisting from roof beams will be allowed. The structural engineer is not concerned about the capacity of the mechanical frame. Walt Cohen should be contacted to ensure his estimate includes work and materials for attaching the HX to existing frame. After placing the HX, the situation will be reviewed to determine if reinforcement to control deflections is required.
4. Monitoring Installation and Start-up: So long as work is finished before 31 March, as expected, no problems are foreseen in properly supervising the work.
5. Budget: Budget is very close but it is expected that the project can be completed with available funds.


Sheldon M. Jeter

cs

cc Dr. James Craig, Ga Tech
Mr. John Crane, PRC
Mr. Thomas Hartman, Ga Tech
Mr. Darrel Hester, Shenandoah

Mr. Ray Moore, Shenandoah
Mr. Frank Nelson, Newcomb and Boyd
Mr. Warren Shiver, Newcomb and Boyd
Dr. J. R. Williams, Ga Tech

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March 12, 1979

MONTHLY REPORT -- SHENANDOAH MODIFICATION -- E-15-618

This report covers the work accomplished on Contract E-15-618 (Mod A005 to EY-76-S-05-4942) to date.

The heat exchanger which had delayed the project through January and most of February has finally arrived. It was delivered to the site on 3/5/79 and has been installed as of this date. The bonnett head, tube sheet and tube bundle had been mounted 90° to the desired orientation. In order to correct this condition it would be necessary to remove all the above components and re-install. This would delay the job yet again. Rather than do this, it has been decided to field modify the working drawings and use the HX as delivered.

In addition, the as built drawings at the site were found to be in error as to the routing and lengths of several pipes. Modifications to the working drawings have again been made to solve this problem.

The modifications mentioned above were discussed at the site with the mechanical contractor. These changes will cause no delay or extra expense on the job.

Necessary piping components are at the job, and the mechanical work is underway. Control components are in hand, and installation is waiting until the mechanical work is completed. Insulation work on the modules has started, with modification of the sheet metal flashing in progress.

Training of the owner's personnel is scheduled to start next week and will be full-time for approximately one week.

Construction is now moving swiftly, and it is expected that the project will be completed on time. While money is tight, it is anticipated that it will be adequate.

Thomas L. Hartman III

CS

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

July 26, 1979

(404) 894-3354

ENGINEERING COLLEGE
OFFICE OF THE DEAN

MEMORANDUM

TO: PRC: John Crane
Shenandoah: Ray Moore, Darrel Hester
N&B: Warren Shiver, Frank Nelson
GIT: Richard Williams, Jim Craig, Tom Hartman

FROM: Sheldon M. Jeter

Topical Report: Shenandoah Solar Community Center

Site Visit: 22 July 1979

We arrived at the building at 10:00 a.m. The weather was usually overcast all day.

Repairs on the roof were continued, and we worked for the rest of the day attempting to fix the remaining leaks in the array. We had very little success as the unrepaired leaks that remain are the most difficult to find and fix. Leaks remain in the following collectors and modules:

Row	Module	Collector	
5	1	1	under second riser
6	5		new coupling
8	6	6,5,1	risers
9	7	6	obscure leak

Project Meeting: 23 July 1979

The undersigned met with Warren Shiver, Frank Nelson, and Steve Brunning at Newcomb and Boyd's office at 9:00 a.m. The following questions were raised concerning the reported high gas consumption during June.

- (1) Do the space thermostats inhibit chilled water storage in the absence of a contemporary demand?
- (2) The entry of solar-heated water into the generator loop restricted as was the case early last summer?
- (3) What is the actual situation relative to gas consumption? Obviously we need the monitoring system to be able to uncover the source of this problem if it exists.

The problem of preventing overflow of the glycol-holding tank was discussed. A proposed solution is the installation of a McDonnell-Miller 25A boiler make-up valve (a self-contained float valve) to limit the water level allowed in the holding tank. This appeared to be a practical and positive solution. Auxiliary measures might include installation of air vents in the array

headers (for example a Hoffmann No. 78 or 79) to vent compressed vapor once the liquid level clears the roof.

Newcomb and Boyd will issue a final site visit report this week.

Other Activities:

Final report to be prepared next week.

Copies of working drawings (schematic and mechanical assembly) are needed for final report. Tom Hartman will obtain these from Walter Cohen.

Repairs will be continued next weekend. Plans are to complete insulation of array and fix remaining leaks. Some problems are obtaining transportation and hourly help over the weekends.

Valves and fittings will be purchased now to modify the holding tank for overflow prevention, but the work will necessarily be delayed until early fall when the tank is empty.

Important Operational Notes:

It is important that we at Georgia Tech be kept advised as to system problems such as excessive fuel consumption and maintenance. Possibly an O&M logbook should be maintained during the course of the upcoming monitoring and evaluation contract.

Special caution should be taken to avoid damaging collectors because of excessive temperature or pressure when modules are isolated because of leaks. It should be certain that a module has a leak before it is isolated otherwise the vapor pressure in the stagnant collectors is sure to rupture the collector risers. It would be preferable that, so long as the array is filled with water, collectors with leaks not be fully isolated to prevent high pressure and temperature; therefore, it is recommended that the insulation valves be kept at least partially open. Only on the day prior to scheduled repairs should the effected module be completely isolated to allow it to dry out and then only if the leak is big enough to relieve any internal vapor pressure.

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

TO: Shenandoah: Ray Moore, Darrel Hester
GIT: J. R. Williams, Jim Craig, Tom Hartman

FROM: Sheldon M. Jeter *smj*

Trip Report: 29 July 1979 *U*

Tom Hartman, Bob Weinstein and I arrived at the building around 2 P.M. The sky was partly cloudy which made for usually very uncomfortable working conditions on the roof. A wrench we had been using was missing from our tool box which resulted in our having to move the oxygen and acetylene tanks while still connected to the torch. This is difficult enough in general, but since the tanks quickly become too hot to touch such a situation becomes a real aggravation. Collector water temperature is very high (c. 200°F) which indicated some control system problem. We probably have the boiler carrying most of the load. The building thermostats were set at 70°F and 72°F rather than the legal 78°F, and such a low setting will inhibit solar participation. Building was around 70°F.

We continued to repair leaks that remain on the roof. Most of the leaks noted in the last report were fixed; however, two new leaks were discovered which is very discouraging. At present the leak situation is as follows:

ROW	MODULE	COLLECTOR	
9	7	6	an old leak in an obscure location
* 7	7	1	new leak, cause unknown, 6th riser(?)
* 8	6	7	new leak, cause unknown, could have been overlooked previously
** 5	4		<u>not</u> a leak in collector, leaking PRV
* These modules should not be isolated as the leakage is not excessive, and further stagnation would likely cause more damage.			
** Caution is necessary not to confuse this leak with a collector leak. It is only the pressure relief valve (PRV) not a collector. Do not isolate this module.			

We were delayed in repairing insulation because when our personnel got to the building on Friday they couldn't gain entrance. This was a failure of coordination on our part. We hope to complete most of the insulation installation before 4 August.

SMJ/lp

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

(404) 894-3354

ENGINEERING COLLEGE
OFFICE OF THE DEAN

MEMORANDUM

TO: Distribution
FROM: Sheldon M. Jeter
DATE: September 10, 1979
RE: Shenandoah Building Trip Report, August 7, 1979.

1. Remaining leaks

<u>row</u>	<u>module</u>	<u>collector</u>	
9	7	6	old leak
*7	4	7	probably an old leak

* not shut off, allow it to remain leaking

- A broken coupling between the motor and pump P-10 (which circulates potable water to hot water generator and/or buffer tank) preventing production of DHW. Darrell will fix this.
- Tom has discovered the likely cause of excessive fuel gas consumption. Control valve CV-5 is improperly adjusted so that it remains open even when there is no demand for boiler assist. The system was operated by solar alone for at least 4 hours by manually closing this valve. The proportional controller should be adjusted to correct this. Tom will try to accomplish this on Friday.
- To keep the meeting rooms comfortable with the space thermostats set at 78°F, it is recommended that the blinds be kept closed and/or the dampers be adjusted to favor cooling this area rather than the gym.
- A reminder to Shenandoah. The chiller is due for a recharge of isopropyl alcohol as outlined in the maintenance manual. This is important to protect seals and moving parts.

SMJ:rl

Distribution: Tom Hartman
Ray Moore
Darrell Hester
J. R. Williams

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

ENGINEERING COLLEGE
OFFICE OF THE DEAN

1404) 894-3354

MEMORANDUM

TO: J. R. Williams, J. I. Craig, Tom Hartman,
Ray Moore, Darrel Hester (Shenandoah Corp.)

FROM: Sheldon Jeter

RE: Shenandoah Building Trip Report, Friday 14 September

DATE: September 20, 1979

Tom and I arrived at the building around 8:30 a.m. We renewed the Rubatex insulation on module 7-3, taped the joints, and applied two coats of exterior latex paint.

We installed preformed fiberglass insulation on modules 8-6 and 7-7 and repaired split Rubatex on the riser to module 2-6.

We inspected the array. At least one PRV will need to be replaced on row 5. There is a possible leak in module 3-3 but it could as easily be condensate or rainwater draining. Module 9-7 remains isolated. This is the only isolated module the other 62 are in good shape. The leak in 9-7 cannot be located at present.

Tom inspected the controls to see if he could find the problem which is disabling the chiller. Apparently there is a malfunction in a thermostat, but since they were locked-up, he could not diagnose the problem.

We plan to change to winter mode of operation in early October. It may be necessary for Shenandoah to provide additional anti-freeze for the change over.

SMJ:rl

Newcomb & Boyd

Project Report

Copies To Mr. Sheldon M. Jeeter

Project Shenandoah F. P.

Ga. Institute of Technology

Number 78 N 159

Engineering College/Office of the Dean

Report Date 8/7/79

Atlanta, Georgia 30332

Visit Date 7/24/79

From F. H. Nelson

Trade HVAC

Jobsite visit indicates that all freeze protection modifications have been completed in accordance with Drawing SD-1A Revision 7 dated 11/17/79 with one exception:

The 1" pipe from the chill water expansion tank to the chill water loop was not installed.